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(54) Electrical signal generation

(57) For digitally generating a chirp signal, a ROM 5 stores digital numbers representing successive values of the chirp, and a counter 8 is driven by pulses derived from a timing and clock unit 6 so as to cause the ROM 5 to output the digital numbers in turn. A digital to analogue converter 12 converts the signals into an analogue output which is mixed with a carrier signal derived from a local oscillator 18. A band pass filter 20 selects the upper or lower sideband to produce the required chirp output on line 22. Also disclosed is a modification to the arrangement to enable the bandwidth of the chirp to be increased.

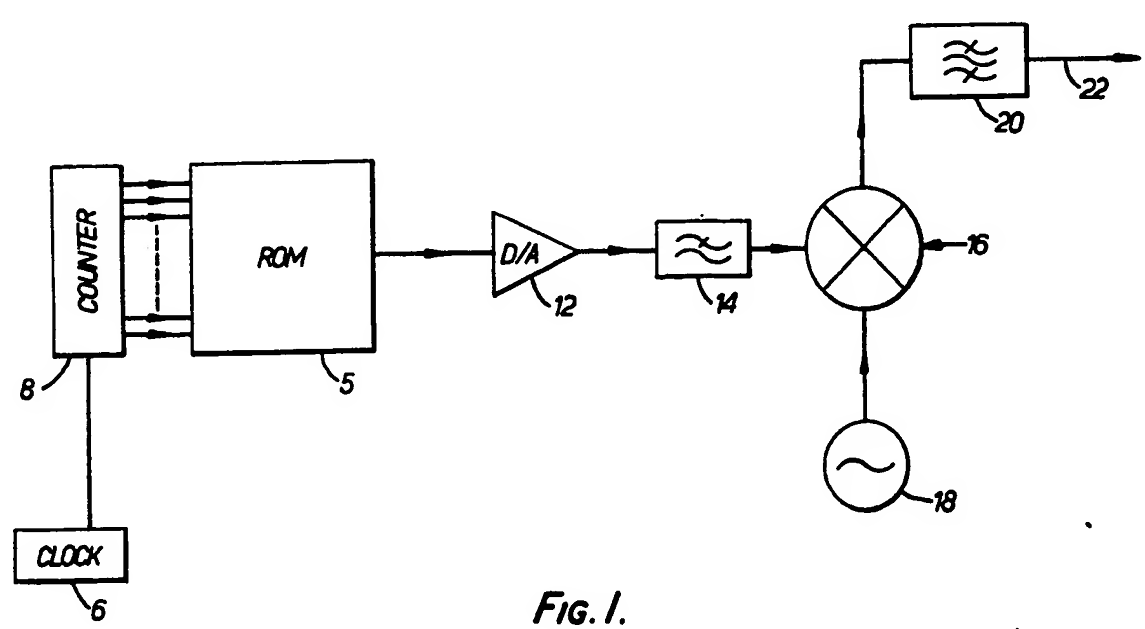

FIG. 1.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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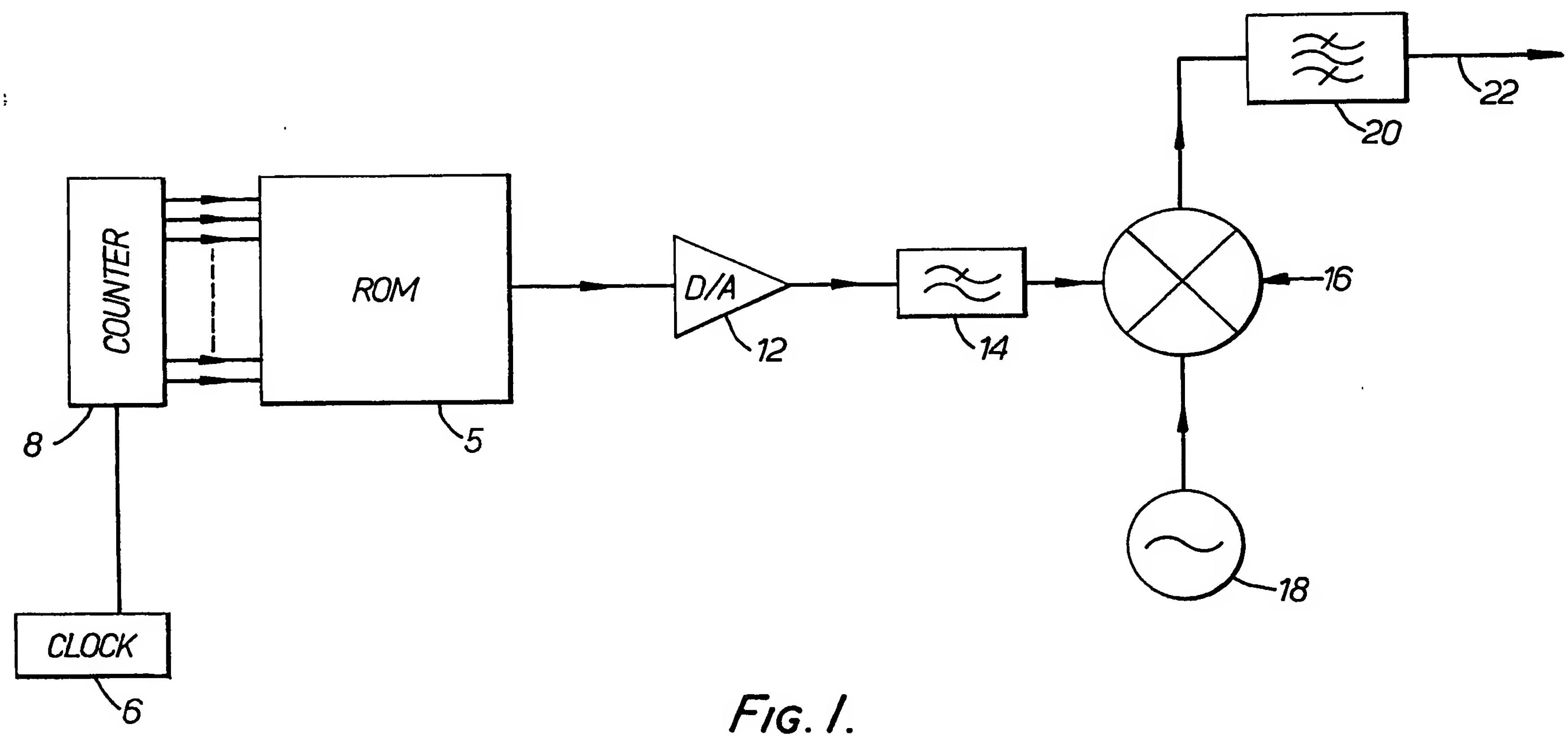


FIG. 1.

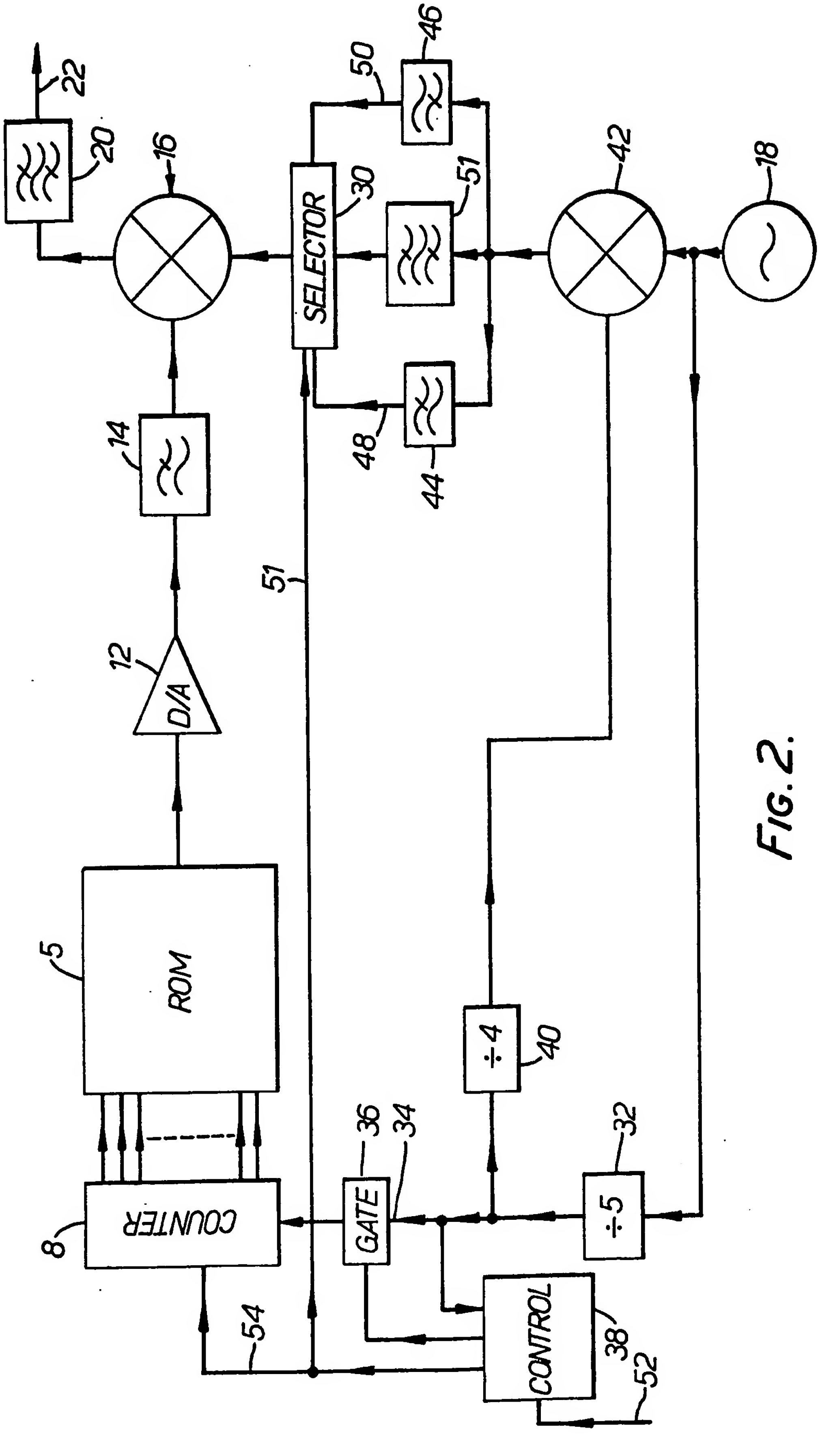

22
20
16
50
46
SELECTOR
30
51
42
18
14
48
44
51
12
D/A
5
ROM
40
÷4
36
34
32
8
COUNTER
GATE
÷5
54
CONTROL
38
52

FIG. 2.

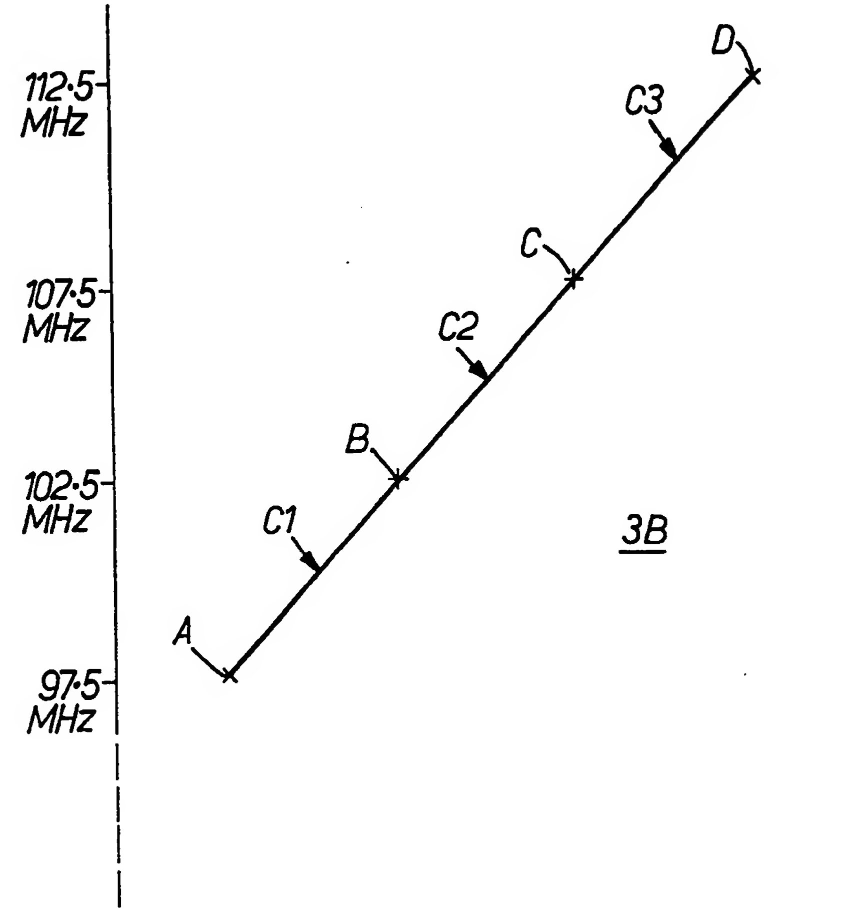
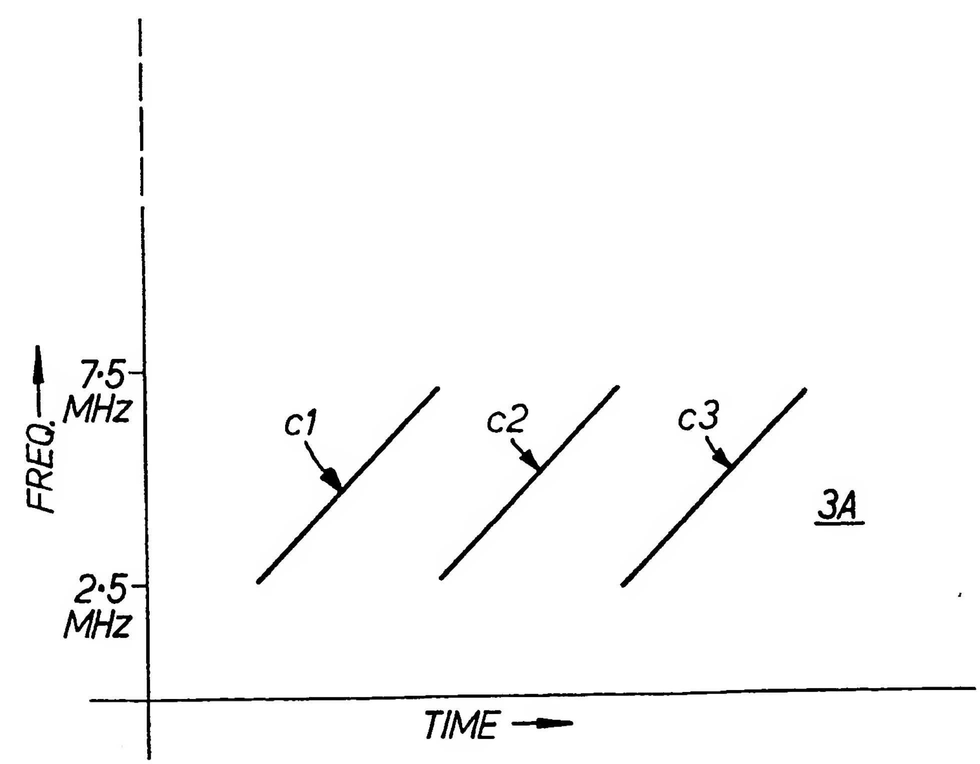

112·5 MHz
107·5 MHz
102·5 MHz
97·5 MHz
D
C3
C
C2
B
C1
A
3B

FIG. 3.


FREQ.
7·5 MHz
2·5 MHz
c1
c2
c3
3A
TIME

SPECIFICATION

Improvements in and relating to electrical signal generation

The invention relates to electrical signal generation. More specifically, the invention relates to arrangements for generating signals having a frequency modulated wave form such that the frequency at any point on the wave form is predetermined. Such signals are referred to as "chirps" and are so-called in this Specification. They may comprise waveforms whose frequency is swept progressively from one limit to another.

Various novel features of the invention will be apparent from the following description, given by example only, of an electrical circuit arrangement embodying the invention for generating chirp signals, reference being made to the accompanying diagrammatic drawings, in which:

Figure 1 is a block diagram of one of the arrangements;

Figure 2 shows a modified form of the arrangement of Fig. 1 for generating chirp signals of increased bandwidth; and

Figure 3 is a diagram for explaining the operation of Fig. 2.

More specifically to be described is the generation of a frequency modulated electrical signal of pre-determined time duration and whose frequency at any time instant is predetermined in which a plurality of predetermined values are stored each representing the value of the said electrical signal at a respective said time instant, and in which the stored values are output successively whereby to generate the said electrical signal.

Advantageously, the stored values are stored as respective digital numbers and are output through a digital to analogue converter.

In a more specific sense, there will be disclosed below an arrangement for generating a chirp of predetermined time duration and whose frequency sweeps in a predetermined manner from one end of a predetermined frequency range to the other end thereof, comprising storage means for storing a plurality of digital numbers each representing the value of the electrical signal at a predetermined time instant within its duration, control means operative to activate the storage means to output the digital numbers in succession, digital to analogue converting means operative to convert the digital numbers into respective analogue values constituting an analogue signal, signal generating means operative to generate a predetermined carrier signal, mixing means operative to mix the analogue signal with the carrier signal, and bandpass filter means for selecting one or other of the side band outputs of the mixing means as the desired chirp.

Advantageously, the control means comprises a counter and timing means for regularly stepping the counter through its count sequence whereby to address the storage locations of the storage means in turn. Drive pulses for the counter may be derived from the said carrier signal.

Advantageously, the signal generating means comprises means for producing a plurality of reference signals each having a predetermined and different frequency, and the control means may comprise selecting means operable to select any one of these signals and to feed it to the mixing means as the carrier signal, and a control unit operative to control the feeding of the drive pulses to the counter so that the said analogue signal is successively repeated and to control the selecting means so as to select each of the said reference signals as the carrier signal in turn, the control unit being so operative and the frequencies of the reference signals having such values that the sideband outputs of the mixing means selected by the bandpass filter means together constitute a chirp which changes progressively in frequency.

The signal generating means may produce the reference signals and the drive pulses by division from the output of a master oscillator. Instead it may produce the reference signals and the drive pulses by means of a respective oscillators all of which are phase-locked to a master oscillator.

The foregoing are exemplary of and not exhaustive of the various features of the circuit arrangement now to be more specifically described.

The chirp to be produced by the circuit arrangement may have band width of, say, 5MHz and a duration of, say, 25 microseconds. The parameters of the chirp, that is, the phase and frequency at specified time instants during its duration, are defined by respective samples such as respective eight-bit binary numbers, for example in a suitable non-volatile store 5. When a chirp is to be generated, a clock generator 6, operating at 20MHz for example, feeds clock signals to a counter 8 which produces a sequence of output address signals on lines 10 which cause the eight bit numbers to be output by the store 5 in turn and fed to a digital to analogue converter 12. If the frequency of the clock 6 is 20 MHz, this produces 500 clock pulses within the 25 micro second duration, and the store 5 is therefore arranged to store 500 digital numbers to define the chirp, each specifying an instantaneous amplitude for the chirp. The digital to analogue converter 12 thus produces corresponding analogue outputs which are passed through a low pass filter 14 to one input of a mixer 16.

The stored digitial numbers are arranged such that the centre frequency of the signal produced by the digital to analogue converter

12 is at 5 MHz (in this example), and it therefore sweeps in frequency between 2.5 and 7.5 MHz. The mixer 16 mixes this signal with an input from a local oscillator 18 at, say, 100 MHz, and a bandpass filter 20 selects one or other of the two sidebands produced, the lower sideband extending from 97.5 down to 92.5 MHz and the upper sideband extending from 102.5 to 107.5 MHz. The selected sideband is the desired chirp. If the lower sideband is selected it will be a down-sweeping chirp, that is, sweeping from 7.5 to 2.5 MHz, while if the upper sideband is selected, it will be an up-sweeping chirp.

The lower frequency of the digitally generated signal should be sufficiently high to ensure that the two sidebands produced after up-conversion in the mixer 16 are separated by an amount large enough to prevent interference. In the present example, they are separated by 5 MHz which has been found to be sufficient.

The 20MHz sampling frequency produced by the clock 6 may be increased, to reduce distortion in the chirp, if the operating parameters of the digital components permit.

The up-conversion by the mixer 16, in order to produce the chirp at the desired IF, is carried out, because speed restraints of the digital devices may prevent direct generation of the chirp at the desired IF. However, if such speed restraints do not apply, the chirp may be directly generated, that is, without the need for the mixer and the local oscillator.

In a modification which may have advantages in circumstances where the speed requirements imposed on the ROM 5 are too high, the ROM may be replaced by a high speed random access memory (RAM) which is connected to the ROM so as to receive the required digital signals from the ROM at a relatively low speed immediately prior to the generation of the chirp. The RAM is then addressed at high speed by the counter 8 to generate the chirp.

The chirp produced can have a linear or a non-linear frequency sweep as required. Non-linear sweeps provide a wider range of design options and significant operational advantages.

Figure 2 shows a modified form of the arrangement of Fig. 1, providing an output chirp of increased bandwith, and items in Fig. 2 corresponding to items in Fig. 1 are similarly referenced.

In the arrangement of Fig. 2, the output of the local oscillator 18 is not fed directly to mixer 16 but via a selector switch 30. In addition, it is fed through a divide-by-five divider 32 to produce an output at 20 MHz which is supplied to counter 8 on a line 43 via a control gate 36 and thus produces the clock signals corresponding to those produced by the clock generator 6 in Fig. 1. In the Fig. 2 arrangement, the gate 36 is controlled by a control unit 38.

The 20 MHz output from the divider 32 is also fed through a divide-by-four divider 40 to produce a 5 MHz output supplied to one input of a mixer 42 which also receives the 100 MHz output oscillator 18. Filters 44 and 46 respectively select the lower and upper sidebands (at 95 and 105 MHz) which are fed to the selector switch 30 on lines 48 and 50 while a bandpass filter 51 feeds the 100 MHz output to the selector switch.

The selector switch 30 is controlled by the control unit 38.

The operation of the Fig. 2 arrangement will be described with reference to Fig. 3.

When a start signal is received on a line 52, the control unit 38 opens the gate 36 and sets selector switch 30 so as to pass to the mixer 16 the 95 MHz signal on line 48.

As already explained in conjunction with Fig. 1, the counter 8 is now stepped through at 20 MHz, in response to the sampling signals on line 34, and the digital to analogue converter 12 thus produces a signal output centred at 5 MHz and with a 5 MHz bandwidth, as shown at C1 in Fig. 3A. This waveform is mixed with the 95 MHz output supplied to mixer 16 through switch 30 and therefore produces a chirp C1 on line 22 which sweeps from a lower frequency of 97.5 MHz to an upper frequency of 102.5 MHz as shown between A and B in Fig. 3B, (assuming that the bandpass filter 20 is selecting the upper sideband).

When the control unit 38 determines that the chirp output has been completed, it re-sets the counter 8 by means of a re-set line 54 and sets selector switch 30 so as to feed the 100 MHz output from oscillator 18 to the mixer 16. The counter 8 is then stepped through its counts again, by the 20 MHz signal on line 34, and the digital to analogue convertor 12 therefore produces a second signal output, shown at c2 in Fig. 3A this of course being identical with the signal with a carrier of 100 MHz, and the result is an output chirp C2 on line 22 at a centre frequency of 100 MHz, sweeping from 102.5 MHz to 107.5 MHz, that is, between points B and C in Fig. 3B.

This process is repeated again, so that the digital to analogue convertor 12 produces a third signal output c3, identical with the signals C1 and C2 previously produced, but during production of the third signal c3, the control unit 38 sets the selector switch 30 to select the 105 MHz output on line 50. Therefore, output line 19 carries a chirp C3 sweeping from 107.5 MHz to 112.5 MHz, that is, between points C and D in Fig. 3B.

In this way, therefore, a composite chirp output is produced on line 19 having a bandwidth three times the bandwidth of the basic chirp produced by the digital to ana-

logue converter 12, but only using a single set of stored digital numbers, the composite chirp sweeping from a lower frequency of 97.5 MHz to an upper frequency of 112.5 MHz.

It is important that there should be little or no discontinuity in output, or phase change, at the change-over points (B and C in Fig. 3) where chirp generation is re-started and the carrier frequency is changed. This is mainly ensured by the fact that a single master oscillator, oscillator 18, is used, to generate the three carrier frequencies required as well as the sampling frequency driving the counter 8. Instead, however, the three carrier frequencies and the sampling frequency could all be generated from individual oscillators all phase-locked to a master oscillator.

In the Fig. 2 embodiment, the mixer 16 should be a mixer producing a single side-band output. This is necessary because the width of the passband which the filter 20 is required to have, in order to pass the composite chirp, is such that it would be sufficient to pass part of the other sideband as well.

It will be appreciated that technique illustrated in Fig. 2 can be modified to produce an output chirp of stil greater bandwith.

In the system described with reference to Figs. 2 and 3, the same chirp is produced several times, each time at a different centre frequency, so as to produce a final, composite, chirp of increased bandwidth. This arrangement is therefore suited to the production of a linear composite chirp. However, it is not essential that each individual chirp making up the composite chirp be the same. The arrangement shown in Fig. 2 could be modified so that the individual chirps were not all identical but were mutually arranged to produce a composite chirp giving a required non-linear frequency sweep. The data stored for each chirp would thus be stored in a different part of the store. In fact, in many applications, it is likely that the composite chirp would have a non-linear frequency sweep that was nevertheless symmetrical about the centre frequency of the composite chirp and some sharing of the storage space might therefore be possible. Even in such cases, however, it may be preferably still to use separate storage space for each individual chirp because this enables local variations to compensate for distortion effects in other parts of the system. It is believed that the modifications necessary to the circuitry of Fig. 2, in order to enable individual chirp data to be accessed from different parts of the ROM 5, would be clear to those skilled in the art. For example, the counter 8 could be connected to the ROM 5 through a suitable selector switch which would be switched each time the counter was reset, so as to address different parts of the ROM.

CLAIMS

1. A method for the generation of a frequency modulated electrical signal of predetermined time duration and whose frequency at any time instant is predetermined, in which a plurality of predetermined values are stored each representing the value of the said electrical signal at a respective said time instant, and in which the stored values are output successively whereby to generate the said electrical signal.

2. A method according to Claim 1, in which the stored values are stored as respective digital numbers and including the step of converting them into analogue from when they are output.

3. Apparatus for generating a frequency modulated electrical signal of predetermined time duration and whose frequency at any time instant is predetermined, comprising means for storing a plurality of predetermined values each representing the value of the said electrical signal at a respective said time instant, and output means for outputting the stored values successively whereby to generate the said electrical signal.

4. Apparatus according to Claim 3, in which the stored values are stored as respective digital numbers and in which the output means includes a digital to analogue converter.

5. An arrangement for generating a chirp of predetermined time duration and whose frequency sweeps in a predetermined manner from one end of a predetermined frequency range to the other end thereof, comprising storage means for storing a plurality of digital numbers each representing the value of the electrical signal at a predetermined time instant within its duration, control means operative to activate the storage means to output the digital numbers in succession, digital to analogue converting means operative to convert the digital numbers into respective analogue values constituting an analogue signal, signal generating means operative to generate a predetermined carrier signal, mixing means operative to mix the analogue signal with the carrier signal, and bandpass filter means for selecting one or other of the side band outputs of the mixing means as the desired chirp.

6. An arrangement according to Claim 5, in which the control means comprises a counter and timing means for regularly stepping the counter through its count sequence whereby to address the storage locations of the storage means in turn.

7. An arrangement according to Claim 6, in which drive pulses for the counter are derived from the said carrier signal.

8. An arrangement according to any one of Claims 5 to 7, in which the signal generating means comprises means for producing a plurality of reference signals each having a predetermined and different frequency, and

the control means comprises selecting means operable to select any one of these signals and to feed it to the mixing means as the carrier signal, and a control unit operative to control the feeding of the drive pulses to the counter so that the said analogue signal is successively repeated and to control the selecting means so as to select each of the said reference signals as the carrier signal in turn, the control unit being so operative and the frequencies of the reference signals having such values that the sideband outputs of the mixing means selected by the bandpass filter means together constitute a chirp which changes progressively in frequency

9. An arrangement according to Claim 8, in which the signal generating means produces the reference signals and the drive pulses by division from the output of a master oscillator.

10. An arrangement according to Claim 8, in which the signal generating means produces the reference signals and the drive pulses by means of respective oscillators all of which are phase-locked to a master oscillator.

11. A method of chirp generation, substantially as described with reference to Fig. 1 of the accompanying drawings.

12. A method of chirp generation, substantially as described with reference to Figs. 2 and 3 of the accompanying drawings.

13. An arrangement for chirp generation, substantially as described with reference to Fig. 1 of the accompanying drawings.

14. An arrangement of chirp generation, substantially as described with reference to Figs 2 and 3 of the accompanying drawings.

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